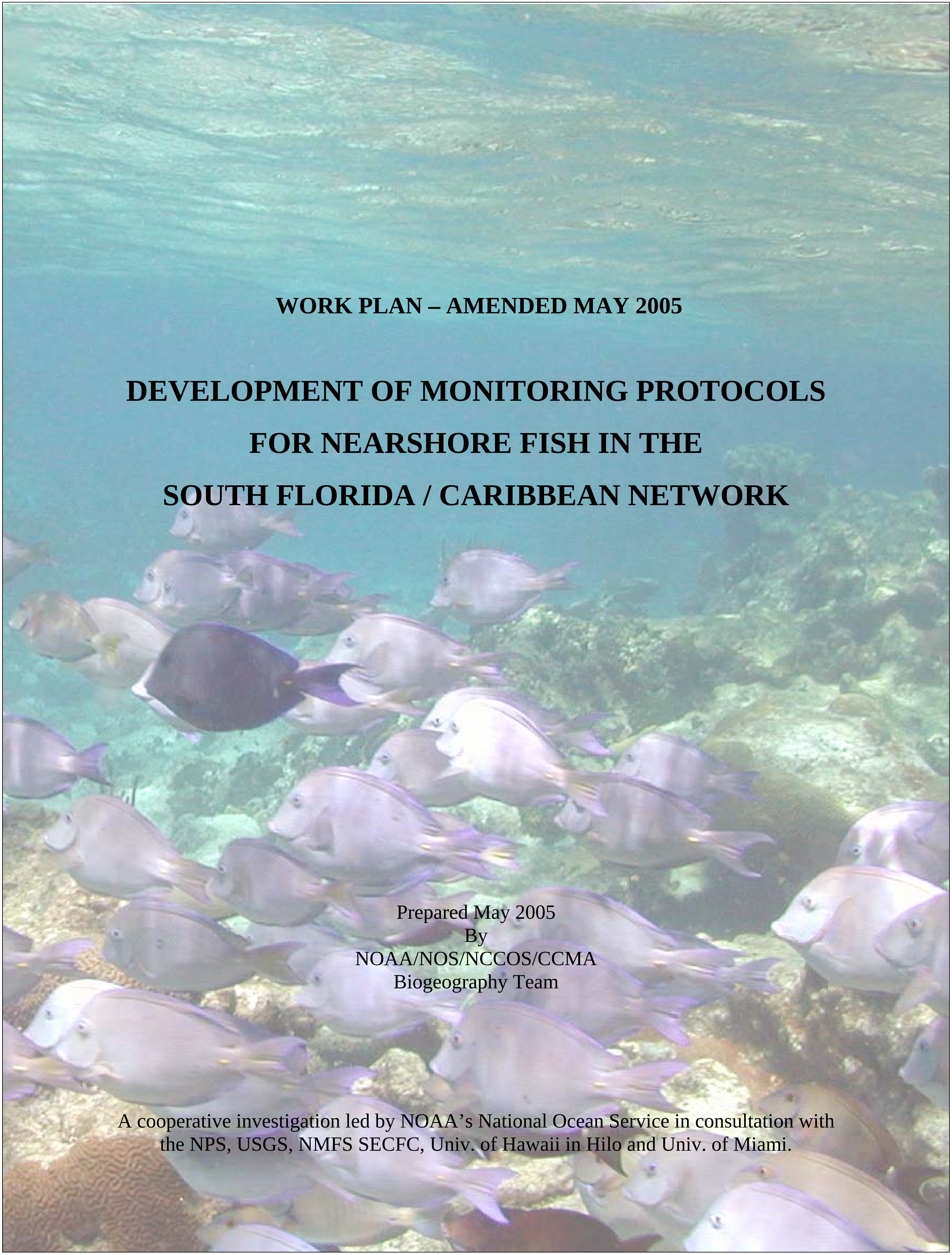


WORK PLAN – AMENDED MAY 2005

DEVELOPMENT OF MONITORING PROTOCOLS FOR NEARSHORE FISH IN THE SOUTH FLORIDA / CARIBBEAN NETWORK

Prepared May 2005
By
NOAA/NOS/NCCOS/CCMA
Biogeography Team

A cooperative investigation led by NOAA's National Ocean Service in consultation with the NPS, USGS, NMFS SECFC, Univ. of Hawaii in Hilo and Univ. of Miami.

GOAL

The National Ocean Service's (NOS) Biogeography Team in collaboration with the National Park Service (NPS), United States Geological Survey (USGS), National Marine Fisheries Service's (NMFS) Southeast Fisheries Science Center, University of Hawaii (UH) and University of Miami (UM) will develop monitoring protocols for nearshore fish. The protocols are for use by the NPS in the South Florida / Caribbean Network (SFCN).

MONITORING OBJECTIVES

Three monitoring objectives were produced to explicitly guide monitoring protocol production. Each objective was selected to correspond with current and anticipated management issues within the SFCN. The objectives are to detect:

1. Change in community structure;
2. Change in selected economically and ecologically important species, families, and trophic groups; and,
3. Differences in the above inside versus outside of Marine Protected Areas.

BACKGROUND

Nearshore fishes are essential components of Caribbean coastal ecosystems and economies. Unfortunately, they are under threat from a wide variety of natural and anthropogenic stressors. Overfishing, pollution and habitat loss are key threats. Recent studies have shown shifts in reef assemblage structure (Garrison et al., 1998), declines in the abundance of exploited species, especially grouper and snapper (Beets and Rogers, 2002), shifts in size structure (Beets, 1997) and drastic habitat loss (Burke et al., 1998). These trends are likely to persist as coastal populations continue to grow.

A network of parks managed by the NPS offers nearshore fishes in the Caribbean and off the coast of Florida a measure of relief from stressors. These parks are collectively known as the South Florida / Caribbean Network (SFCN). Seven parks make up the SFCN including the Virgin Islands National Park (VIIS), Biscayne National Park (BISC), Dry Tortugas National Park (DRTO), Big Cyprus National Park (BICY), Everglades National Park (EVER) and Salt River Bay National Historic Park and Ecological Preserve (SARI).

Nearshore fish management in the SFCN is becoming an increasingly complex and challenging issue, and park managers are being asked to provide scientifically-credible data to defend management actions. A comprehensive long-term monitoring program can capture rigorous data and help managers better understand past, current and predicted fish resources. This work plan is the first deliverable of a nearshore fish monitoring protocol project which will help in this endeavor. It is intended that the protocols will offer guidance to all parks in the SFCN along with the Virgin Islands Coral Reef National Monument (VICR) and Buck Island Reef National Monument (BUIS).

A large amount of variability in ecological condition, size, and management capability exists among SFCN parks. Given this variability, no single sampling design is capable of adequately monitoring fish resources in all parks. To ensure all parks and monuments in the SFCN are provided a useful method to monitor nearshore fish, sampling designs spanning a range of personnel, time and material requirements will be reported. This strategy will allow each park to tailor monitoring programs to park-specific constraints and monitoring agenda.

Most NPS protocols are developed for a single park and thus do not need to take into consideration diversity among parks. We propose to assemble several park-specific sampling designs into a single, all-inclusive protocol document. Each sampling design will come from select monitoring programs already in use within SFCN parks. The use of existing sampling designs will enhance data credibility and produce a longer contiguous temporal series of information. Ultimately, the incorporation of distinct designs will create an objective-oriented, comprehensive and functional monitoring protocol document for nearshore fish within all SFCN parks.

This report is a modification of the first work plan sent in September 2005. It reports an updated schedule, document structure and analytical methodology. The most significant change corresponds to the inclusion of three sampling designs, instead of one. We expect the amendments will enhance the practicality and thoroughness of the protocols.

PROJECT OVERVIEW

Nearshore fish monitoring requires the collection and analysis of measurements over time. To ensure that a change in the condition of a fish community is factual and not a product of the measurement process (e.g. a result of measurements taken by different people or in different ways) a strict, detailed protocol must be produced and followed.

The protocols produced in this project will describe distinct sampling designs along with a suite of useful analyses to help effectively monitor nearshore fish within the SFCN. The sampling designs incorporated in this protocol are 1) Single-staged random stratified sampling, 2) Multi-staged random stratified sampling, and 3) Reference site sampling. The designs differ in the assumptions and statistics used, as well as the amount of time, personnel and material resources required for their completion. It is anticipated that each park will choose a sampling design based on park-specific constraints (i.e. financial and personnel) and monitoring objectives.

The protocols will be tailored specifically to nearshore fish within the SFCN through analysis of data obtained from existing fish research programs (Ault et al., 2002; Friedlander et al., 1999; NOAA, 2004). Data obtained from the DRTO, VIIS, VICR and BUIS will help establish spatially-explicit baseline mean and variance estimates for fish communities. Ultimately, these population parameter estimates will be used to determine sample size and monitoring duration requirements for each sampling design.

The bulk of the protocol will describe general guidelines for nearshore fish monitoring applicable in all parks within the SFCN. The general guidelines will be supplemented by case studies offering details into each of the three sampling designs. The case studies are intended to help park managers fine-tune fish monitoring programs according to park-specific needs and constraints. For instance, the general guidelines will describe useful methods to calculate sample size for any dataset, but the case studies will provide sample size requirements for several exemplary datasets collected in a particular park.

Project Period

August 1, 2004 – September 1, 2005. The updated and obsolete project timelines are shown in *Figure 1.*

PROJECT TASKS

Task 1 – Work Plan

Initial (Completion Date: October 1, 2004)
Amended (Completion Date: May 1, 2005)

There will be several meetings between NOS, USGS, UH, NMFS and NPS personnel to determine the objectives, tasks, deliverables and schedule of the project. A formal work plan will be produced from information gathered at these meetings and serve as a blueprint for future work. The work plan will be circulated to interested parties in order to receive additional input. The work plan is an evolving document and may change as new information becomes available at any stage during the project.

Deliverable

1. Work Plan - Amended May 2005 (This Document)

Task 2 – Protocol Outline

(Completion Date: May 1, 2005)

A table of contents, Appendix 1, outlines the structure of the protocol document. The basis for the selected structure is to provide information suggested by Oakley et al. (2003) and the NPS (2004) for multiple sampling designs and their corresponding analytical methods.

Deliverable

2. Table of Contents (Appendix 1)

Task 3 – Non-NPS Narrative Sections

(Anticipated Completion Date: July 1, 2005)

The protocol document consists of 7 chapters which make up the narrative, three case studies and Standard Operating Procedures (see Appendix 1). The document is to be a collaborative effort with separate sections to be written by different authors. The attached table of contents (see Appendix 1) lists each major section and the corresponding authors responsible for their completion. All non-NPS narrative work is scheduled to be completed by July 1, 2005.

Deliverable

1. Non-NPS sections listed in Appendix 1

Task 4 – Case Studies

(Anticipated Completion Date: August 1, 2005)

Case studies will offer detailed information to supplement sampling designs in the narrative. These sections should be written as a methods and materials section of a peer reviewed journal article. Situations particular to an area or sampling design, such as specific locations for reference site sampling, sampling extents of a particular park or unique statistical methods, should be described in this section.

In addition, each case study will include sample size requirements according to the deliverables noted below. Identical datasets will be used for all sampling designs so that comparisons can be made among methods. Data will be altered if necessary to conform to all assumptions of planned tests.

<u>Deliverables</u>

1. Narrative of Methods and Materials.

2. (For stratified sampling monitoring programs only) A table containing the following information for datasets specified in Column 1 of Table 1:
   - The grand mean of annual sample means and its standard error from the five most recent study years
   - The grand mean of annual sample standard deviations and its standard error from the five most recent study years
   - Annual sample size requirements within 95% confidence bounds of:
     i. 5% precision of the grand mean
     ii. 10% precision of the grand mean
     iii. 20% precision of the grand mean

   See appendix II for methods used by the Biogeography Team to determine annual sample size requirements.

Table 1: Summary statistics of annual metrics and sample size requirements to achieve 95% confidence bounds within defined precisions of the grand mean. Standard errors for the grand means and standard deviations represent variability among the five most recent study years. All datasets have been stratified by habitat. The data for pooled species richness is genuine.

Taxonomic Grouping	Metric	Mean (SE)	SD (SE)	Annual Sample Size Requirements		
				5%	10%	20%
Pooled Species	Richness	11.95 (0.75)	4.45 (0.12)	212	54	14
Pooled Species	Abundance					
All Commercial Serranidae	Abundance					
All Commercial Lutjanidae	Abundance					
All Herbivores	Abundance					
Cephalopholis fulvus	Abundance					
Ocyurus chrysurus	Abundance					
All Commercial Serranidae	Biomass					
All Commercial Lutjanidae	Biomass					
All Herbivores	Biomass					
Cephalopholis fulvus	Biomass					
All Commercial Serranidae	Mean Size					
All Commercial Lutjanidae	Mean Size					
Cephalopholis fulvus	Mean Size					

3. A table of minimum monitoring program duration requirements needed to identify exponential and linear trends for datasets specified in Table 1. The following statistical parameters should be used:
    - Exponential trends corresponding to -0.44%, -1.20% and -2.89% per year (equivalent to 10%, 25% and 50% geometric decreases over 25 years) and linear trends of -0.4%, 1% and 2% (equivalent to 10%, 20% and 50% arithmetic decreases over 25 years).
    - Statistical Power = 70%, 80% and 90%
    - Statistical Confidence = 5% and 10%
    - EITHER Sampling Precision = 5%, 10% and 20% of the sample mean (for monitoring stratified samples)
    - OR Number of sampling plots = 1, 2, 3 and 4 plots (for monitoring reference sites)

Table 2: Minimum number of monitoring years required to detect specified trends at specified precision, confidence and power levels. The following results were calculated for species richness in St John using Monte Carlo simulation.

Pooled Species Richness – Exponential Trend

Confidence				5%			10%		
Trend				-0.44%	-1.2%	-2.89%	-0.44%	-1.2%	-2.89%
Precision	5%	Power	70%	40	19	12	35	17	10
			80%	40	20	12	35	19	10
			90%	45	22	12	40	21	12
	10%	Power	70%	40	22	12	40	20	12
			80%	45	23	13	45	21	12
			90%	50	30	15	50	23	13
	20%	Power	70%	>50	30	16	>50	30	15
			80%	>50	35	17	>50	30	16
			90%	>50	35	21	>50	35	19

The software programs MONITOR and TRENDS or Monte Carlo simulations can be used to complete power analyses of temporal trends associated with fixed sampling site designs and the annual means of stratified sampling. Hatch (2003) offers some helpful advice.

4. Examples of all forms used in the field to collect data.

Task 5 – Final Monitoring Protocols

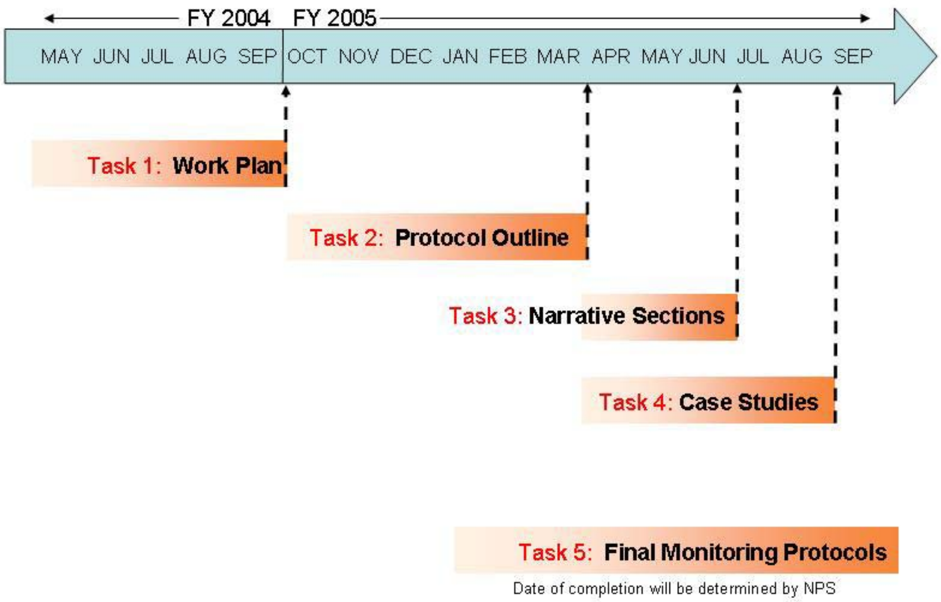
(Anticipated Completion Date: Determined by NPS**)**

NPS will produce narrative sections for which they are responsible (listed in Appendix 1) and all Standard Operating Procedures. All collaborators shall assist NPS in the production of their narrative sections and SOPs. The combination of non-NPS and NPS sections will produce the complete set of viable nearshore fish monitoring protocols.

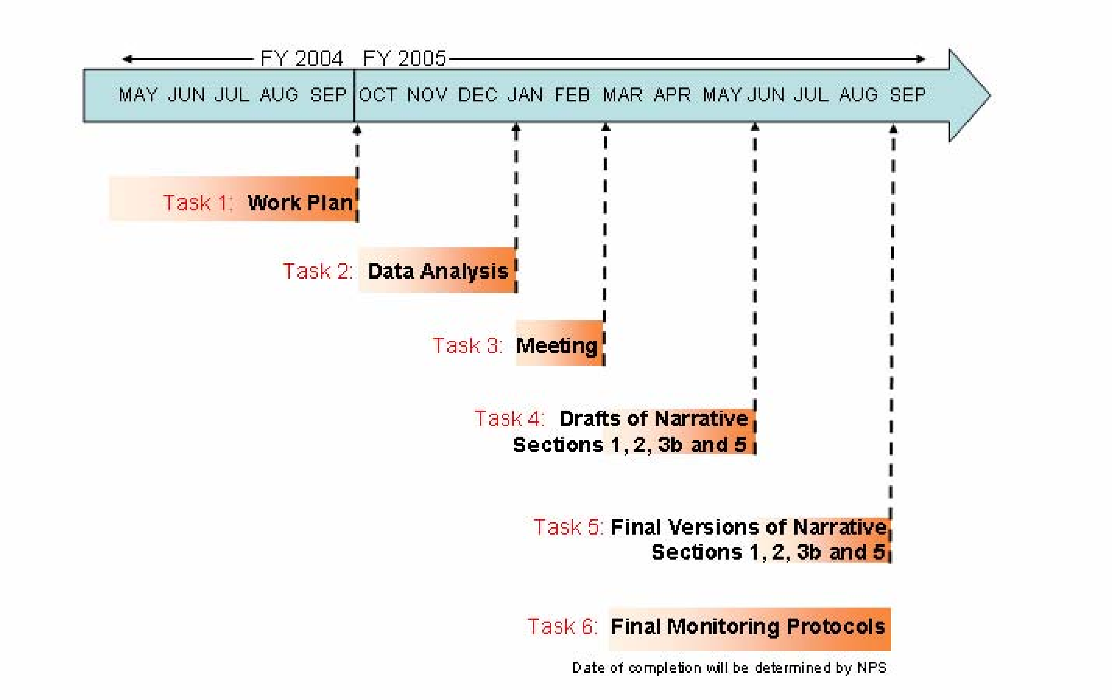
Deliverable

1. Final monitoring protocols

Figure 1: Top – The amended schedule of proposed tasks involved in the production of the nearshore fish monitoring protocol for the National Park Service in the SFCN. The deadlines for each task, also noted in the work plan, relate to the month at which corresponding dashed arrows terminate. Orange highlights correspond to the time period over which work can progress on each task.



Bottom – The obsolete schedule of proposed tasks.



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APPENDIX I – Table of Contents

The nearshore fish monitoring protocol document's table of contents is below. Parties responsible for writing each section are listed in the right-hand column. Shaded sections are to have first drafts finished by July 1, 2005. Case studies are to be completed by September 1, 2005. All other sections are to be completed by NPS and thus have an independent schedule.

5	**Personnel Requirements and Training**	
5.1	Roles and Responsibilities	NPS
5.2	Qualifications	NPS
5.3	Training Procedures	NPS
6	**Operational Requirements**	
6.1	Annual Workload and Field Schedule	NPS
6.2	Facility and Equipment Needs	NPS
6.3	Startup Costs and Budget Considerations	NPS
7	**References**	All
8	**Case Studies**	
8.1	Stratified Sampling in the Virgin Islands National Park	Biogeography
8.2	Stratified Sampling in the Dry Tortugas	Ault, Smith and Bohnsack
8.3	Reference Site Sampling in the Virgin Islands National Park	Beets and Friedlander
9	**Appendices**	
9.1	List of Species Including Trophic Group and Biomass Parameters	Biogeography
9.2	Protocol Development	Biogeography
10	**Standard Operating Procedures**	NPS

APPENDIX II – Statistical Methods

1) The grand mean of all samples was calculated by summing the mean of annual samples and dividing by the number of sampling years. In our case, we used all four years of available data.

We used multiple years of data instead of the most recent year, because the condition of the resource should represent the average condition and not a recent transient condition. We suggest using the five most recent years to estimate the grand mean. Five years is good balance between diluting ephemeral changes and not incorporating large-scale trends.

The mean of each annual sample, $\overline{y}_{st}$, was derived from a stratified random sampling design. Three strata were chosen to maximize the difference between means and standard deviations among strata while keeping the number of strata as low as possible. The strata corresponded to hard, soft and mangrove benthic habitats.

The following methods were used to estimate strata statistics

$$y_h = \frac{1}{n_h}\sum_{i=1}^{n_h} y_{hi} \qquad \text{eq 1}$$

and

$$\overline{y}_{st} = \sum_{h=1}^{H} w_h y_h \qquad \text{eq 2}$$

where y_h = mean of y in stratum h, n_h = number of dives in stratum h, and y_{ih} = metric value at dive site i in stratum h, $\overline{y}_{st}$ = mean of y over all strata and $W_h = N_h/N$ where N_h = area of stratum h and N = total area of all strata.

2) The grand mean of all annual sample standard deviations, $s(\overline{y}_{st})$, was derived using

$$s(y_h) = \sqrt{\sum_{i=1}^{n_h} \frac{(y_i - y_h)^2}{n_h - 1}} \qquad \text{eq 3}$$

and

$$s(\overline{y}_{st}) = \sum_{h=1}^{H} w_h s(y_h) \qquad \text{eq 4}$$

where $s(y_h)$ = the standard deviation of y in stratum h and all other parameters correspond to descriptions provided above.

3) Annual sample size requirements were estimated with

$$n = \frac{CV^2\left(t_{\alpha(2)}\right)^2}{d^2} \qquad \text{eq 5}$$

where CV = the coefficient of variation based on the grand mean and grand standard deviation, t = the two-tailed critical value of the Student's t with n-1 degrees of freedom (for n > 30, t was replaced with 1.96 the corresponding critical value of the Z distribution) and d^2 = the specified precision either 0.05, 0.10 or 0.20. Although, this procedure uses the *t* or *Z* distributions which assume metric normality, we feel deviations are small enough to provide useful estimates. Non-normal metrics may be transformed so that corresponding distributions are as normal as possible. Note: we assume a Neyman allocation scheme will be used to allocate the total sample size, *n*, among strata.

4) The minimum number of years required to achieve a specified power for species richness (data in table 2) was calculated using Monte Carlo simulations. We follow an approach similar to MONITOR where variance is assumed to be static over time, thus conforming to assumptions of regression. However, we differ to MONITOR by incorporating both inter- and intra-annual variances separately. Inter-annual variance was estimated using $s\left(\bar{y}_{st}\right)$ and intra-annual variance was estimated using the standard error needed to obtain an annual mean precision of 5%, 10% or 20%.

A population of annual sample means, with a $\mu = \bar{y}_{st}$ and $\sigma = s\left(\bar{y}_{st}\right)$ was used in each simulation. Here σ estimates inter-annual variability. Each annual sample mean, Y_t, was taken from this population. A total of T annual sample means was selected to model a monitoring program of t years. The intra-annual component of variability was introduced into each Y_t by adding a random term. The random term was based on a distribution with a mean = Y_t and σ = the standard error of Y_{st} required to obtain a given precision. A slope, β, was added to the series of Y_t plotted by year. The slope corresponded to one of six negative linear or exponential trends (-0.44%, -1.2%, -2.89%, -0.4%, -1% and -2% per year) described in Task 4 above. Regressions were performed for a range of years, $5 < t < 50$, and two confidence levels α = 0.05 or 0.10. A total of 1000 iterations were run for each t, precision and confidence level combination. The probability of finding a significant regression slope of annual sample means on year for all iterations was used to estimate the power of a trend analysis on detrended Y_t. Consequently a matrix of power for different t, precision and confidence levels was produced. The lowest year t where power was > 0.70, > 0.80 or > 0.90 was recorded in Table 2.